Australian and Some International Food Standards for Heavy Metals

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Abstract

Heavy metals are potential environmental contaminants with the capability of causing human health problems if present to excess in the food we eat. There may be no visible sign of an illegal or unacceptable level of residue, particularly for toxic elements such as cadmium, lead and mercury. At higher concentrations heavy metals may poison their hosts. Those which obviously damage their host before they adversely affect human health are of lesser concern to the wider community. Well known examples of human heath problems arising from excess heavy metal accumulations in food sources are mercury toxicity from fish consumption at Minemata, and Itai-itai disease associated with excessive cadmium intake. At lower but still unacceptable levels of exposure, effects may be restricted to the physiological or biochemical level, such as behaviour disturbances and learning difficulties.

Regulatory agencies in most countries now seek to protect public health by exercising controls over the chemical composition of specific food types. The process typically involves setting appropriate standards for potentially toxic chemicals in foods; standards which by law should not be exceeded. These or similar agencies then undertake or overview random and/or periodic chemical testing of appropriate samples to ensure compliance.

Many countries have now set legal or at least provisional guideline levels for maximum permitted concentration (MPCs) for one or more heavy metals. A listing with emphasis on cadmium and seafoods has been compiled. There are wide differences, ranging, for cadmium, from 0.05 mg/kg for 'fish and fish products' in several countries to 6.0 mg/kg for 'all foods' in Bangladesh and Pakistan. The Australian MPC for 'fish and the fish content of products

containing fish' is 0.2 mg/kg, based on the fresh weight of the edible portion, expressed as the metal. Australia has adopted an identical MPC for cadmium in crustaceans whereas several countries have adopted higher values. This may reflect the tendency of crustaceans to at times accumulate cadmium, even in apparently pristine marine waters. The Australian MPC for copper in all seafoods with the exception of molluscs is 10 mg/kg fresh weight of the edible portion, expressed as the metal; the corresponding MPC for molluscs is 70 mg/kg.

With respect to food standards in Australia, the Commonwealth and States have agreed 'that uniform food standards should apply across the nation and be regulated by a National Food Authority', a statutory authority answering to the Commonwealth Minister for Community Services and Health. Currently, a combination of Federal and States/Territories arrangements apply. The 'Food Standards Code' of the National Health and Medical Research Council (NHMRC), prepared by direction of the NHMRC Public Health Committee underpins the Australian food standards. The National Food Standards Council was established to give final State/Territory approval or rejection of NHMRC recommendations. Moreover, all NHMRC proposals to amend the Food Standards Code must be endorsed by the National Food Standards Council. Internationally, the Codex Alimentarius Commission of FAO/WHO (Codex) plays a major role in the setting of food standards to ensure fair practices in international trade, and to protect the health of consumers. Both Australia and Papua New Guinea are member countries of Codex, along with 135 other.

Introduction

It is well recognised that chemicals capable of causing human health problems can be present in the food we eat. Among these are a wide range of pesticides, veterinary chemicals, heavy metals, and metalloids such as arsenic. In many cases there may be no visible sign in the food plant or animal of an illegal or unacceptable level of chemical residue, particularly for toxic elements such as cadmium, mercury and lead. At even higher concentrations the same chemicals may poison their hosts. Those which poison their host before they adversely affect human health are of lesser concern to the wider community.

Pesticides and veterinary chemicals have positive benefits when deliberately used to effect controls over particular pests and diseases which would otherwise destroy or disfigure potential food sources. However, if their use is inappropriate or in excess of label recommendations, illegal residues may result. In contrast, concerns about the ingestion of toxic heavy metals (including metalloids) are seldom associated with their deliberate application to potential food sources.

The case against heavy metals has built up over time. For example, the harmful effects of lead were recognised by the Greeks by at least the second century BC (Waldron 1973). Close examination by toxicologists studying cases of poisoning from heavy metals revealed that visible clinical symptoms were likely only in cases of high exposure,

as may occur at an occupational level or following gross contamination of the environment. Well known Japanese examples of the latter are mercury toxicity from fish consumption at Minemata and Itai-itai disease from consumption of excess cadmium.

At lower but still unacceptable levels of exposure – typically from consumption of certain foods – effects may be restricted to the physiological or biochemical level (Hutton 1987). Behaviour disturbance and learning difficulties in children are recognised symptoms of lead poisoning in children (Lansdown 1979), whereas there is some evidence for the association of cadmium, chromium, copper, selenium and zinc in cardiovascular disease (Shaper 1979). Some such as nickel and chrome and perhaps cadmium may be potential human carcinogens (Garner 1979, Tanenaka *et al.* 1983). Table 1 provides summary information on metabolic factors associated with some heavy metals.

Table 1. Key metabolic factors following environmental exposure to heavy metals (adapted from Hutton 1987)

Factor	Lead	Mercury	Cadmium	Arsenic
Key entry pathway	Ingestion, inhalation	Ingestion, inhalation of metal	Ingestion, inhalation; eg. tobacco	Ingestion
Gastrointestinal absorption (%)	approx 10	approx 95	approx 5 *	> 80
Organs accumulating	bone, kidney, liver	brain, liver, kidney	kidney, liver	keratinous tissue
Major routes of excretion	urine	faeces	urine	urine
Biological half-life	approx 20 y	approx 70 d	> 10 y	10-30 h

* Individuals with low iron store or on a calcium deficient diet may absorb as much as 20% (WHO 1985). This is an example that figures on absorption of heavy metals can vary widely for a variety of reasons.

Hamilton (1988) noted that the first legislation to control the adulteration of food or drink occurred in Britain in 1860, in response to a series of exposes on the use of heavy metal salts as colouring matter in food. Regulatory agencies in most countries now seek to protect public health by exercising controls over the chemical composition of specific food types. The process typically involves setting appropriate standards for potentially toxic chemicals in foods; standards which by law should not be exceeded. These or similar agencies then undertake or overview random and/or periodic chemical testing of appropriate samples to ensure compliance. Some details are reviewed in this paper, with emphasis on heavy metal contaminants.

Setting Food Standards

Agencies Relevant to Australia

There is agreement between the Commonwealth of Australia and Australian State Governments 'that uniform food standards should apply across the nation and be regulated by a National Food Authority' (Anon 1990). This will be a statutory authority answering to the Commonwealth Minister for Community Services and Health. When fully operational, work now done by the National Health and Medical Research Council (NHMRC) in the food area will probably pass to the Authority.

At present, a combination of Federal and States/Territories arrangements apply, with States/Territories responsible for administration of Food Law in their own areas of jurisdiction. In Queensland, the *Food Act 1981-1984* and *Food Standards (Adoption of Food Standards Code and General) Regulations 1987* apply.

Responsibility for the quality of food exports and compliance sampling of food imports is a Commonwealth responsibility. The Commonwealth could also regulate the quality of food moving in interstate trade, but has never implemented these powers.

Underpinning Australian food standards is the 'Food Standards Code' of NHMRC, prepared by direction of the NHMRC Public Health Committee (Anon 1987). By Agreement in 1987, the States and the Northern Territory use the NHMRC food standards but retain the right to deviate or not to take into legislation. The National Food Standards Council was established to give final State/Territory approval or rejection of NHMRC recommendations. Moreover, all NHMRC proposals to amend the Food Standards Code must be endorsed by the National Food Standards Council. Industry, consumers, toxicologists, and experts from the States and Northern Territory have input and are represented on NHMRC food committees. The NHMRC itself – now administered by the Minister for Aged, Family and Health Services – was established about 50 years ago to advise the governments of Australia on health matters.

Another significant advisory body, particularly for pesticide residues but increasingly for other contaminants of food – including heavy metals – is the Codex Alimentarius Commission of FAO/WHO (Codex). The primary purposes of Codex, which was established in 1962, are to ensure fair practices in international trade, and to protect the health of consumers. Both Australia and Papua New Guinea are member countries of Codex, along with 135 others (Anon 1989a). Codex has established mechanisms for governments to agree on such things as maximum residue limit (MRL) values for pesticides in foods, extraneous residue limit (ERL) values for pesticides in non-target foods such as fish, and maximum permitted concentrations (MPCs) for heavy metals in foods.

Process and Problems

Establishing MRLs (Anon 1989b,c; Hamilton 1988) and MPC's for specific chemicals and food types typically requires the coordination of two sets of scientific studies as follows:

- toxicological studies on animals, used to set an acceptable daily intake (ADI); and
- residue studies, based on 'good agricultural practice' (or perhaps information from broadly-based surveys in the case of toxic heavy metals).

When established, these legal food standards are intended to reassure consumers, while offering a division between food which is legally (though not necessarily scientifically) fit or unfit to eat and/or move in international trade.

At the international level, the Codex Committee on Fish and Fishery Products has discussed guidelines for mercury contamination in fish (Anon 1987b, 1989a), particularly methyl mercury for which guideline levels of 0.5 mg/kg methyl mercury for fish in general and 1.0 mg/kg methyl mercury for predatory fish (Anon 1989a) were proposed. It has since been decided that further in-depth discussion is necessary (Anon 1989a).

Moreover, the Joint WHO/FAO Codex Committee on Food Additives and Contaminants (CCFAC) at its March 1989 meeting considered proposals for a range of permitted concentrations of lead and cadmium, including 1.0 mg/kg of cadmium in both molluscs and crustaceans, and 0.1 mg/kg of cadmium in fish and fish products. The proposal represented a five-fold increase relative to the present Australian MPC for cadmium in crustaceans (Table 2) but those for molluscs and fish/fish products were half those applicable in Australia. In March 1990, CCFAC took the view that the establishment of international limits for cadmium and lead may be unnecessary and may create new barriers to external trade.

The issue of setting MPCs (or equivalent) for heavy metal contaminants in foods is particularly sensitive, as is any process to effect or recommend changes to existing levels. Moreover, proven violations of heavy metal MPCs attract media attention. This has occurred with such things as cadmium in spanner crabs (The Courier Mail, Feb 18, 1990, p.1 and Feb 25, 1990, p.5) and heavy metals in prawns from Torres Strait (Anon 1989d).

Australian Food Standards for Heavy Metals

Australian food standards for heavy metal contaminants of fishery and some other foods types from the Food Standards Code (Anon 1987a), together with those which previously applied in Queensland in 1982 (Food Standards Regulations 1982) are summarised in Table 2. Conditions which apply to the present MPC's include the following:

- 'metal' includes compounds of a metal;
- antimony, arsenic, and selenium are deemed to be metals;
- MPCs apply to the edible content that is ordinarily consumed
- MPCs for food in dried, dehydrated, or concentrated form are calculated with respect to mass of food following dilution or reconstitution.

It is apparent from Table 2 that different MPCs apply to the various heavy metals and among food types for a given metal. Moreover, an 'all other foods' category is common to all metals. For example, as crustaceans were not specifically mentioned in the 1982 Queensland food regulations for cadmium, the 'all other foods' category of 0.05 mg/kg fresh weight of the edible portion would have applied at that time. For copper, the 'all other foods' category currently applies to all seafoods other than molluscs, the relevant MPC being 10 mg/kg fresh weight of the edible portion.

Table 2. Selected present Australian (Anon 1987a) and superseded 1982 Queensland food standards for heavy metals (mg/kg, calculated and expressed as the metal).

Metal	Food type	Present Australian MPC	Superseded Qld MPC
Antimony	Foods other than beverages and other liquid foods	1.5	1.5
Arsenic	Fish, crustaceans and molluscs (inorganic arsenic only)	1.0	1.0
Cadmium	Crustaceans & the crustacean content of products containing crustaceans	0.2	-
	Fish & fish content of products containing fish	0.2	0.2
	Molluscs & the mollusc content of products containing molluscs	2.0	2.0
	Foods not specifically mentioned in the code	0.05	0.05
Copper	Molluscs & the mollusc content of products containing molluscs	70.0	70.0
	Foods not specifically mentioned in the code (would include crustaceans and fish)	10.0	10.0
Lead	Fish in tinplate containers	2.5	2.5
	Molluscs	2.5	2.5
	Foods not specifically mentioned in the code (includes crustaceans)	1.5	1.5
Mercury	Fish, crustaceans, molluscs & the fish content of products containing fish	Mean of 0.5	Mean of 0.5
Selenium	Foods other than beverages (& other liquid foods) & edible offal	1.0	1.0
Tin	Foods not packed in tinplate containers	50.0	50.0
Zinc	Oysters	1000.0	1000.0
	All other foods excluding beverages & other liquid foods	150.0	150.0

Note: Mean value for mercury as specified applies to a prescribed number of sample units: see Anon (1987a) for further details.

It is possible that at least a few of these MPCs will change over time as more information comes to hand. For example, some already believe it appropriate to review the MPCs for cadmium in food types such as crustaceans. Average weekly intakes of cadmium assessed from surveys (Anon 1988a) and typical Australian diets (Anon 1986) suggest that intake is generally below the Joint FAO/WHO Expert Committee on Food Additives (JECFA) provisional tolerable weekly intake level of 7 μg/kg bodyweight (applicable to both adults and children).

International Food Standards for Heavy Metals

Walker (1988) has summarised international food standards for cadmium applicable in 1986. These were obtained from a British Food Manufacturing Industries Research Association survey reported by L.E. Parker. On that evidence, 19 countries had set regulatory limits for cadmium in foods, but only Australia, Denmark, the Netherlands, and Hungry had set limits for cadmium in particular foods. New Zealand, however, specifically excludes shellfish and probably fish and fish products from its 'other foodstuffs' MPC of 1.0 mg/kg of cadmium, presumably on a fresh weight-edible portion basis. There is emerging evidence that member countries of the Council for Mutual Economic Assistance (Bulgaria, CSSR, Cuba, GDR, Mongolia, Poland and USSR) have set 'maximum allowable concentrations' of cadmium in a wide range of food types. Further details are summarised in Table 3, with emphasis on seafoods.

Surveys of Heavy Metal Residues

Apart from random compliance testing undertaken by state health departments and departments of agriculture, regular surveys are undertaken at the national level to assess chemical contaminants in food, including some heavy metals. The most significant of these are the Australian Market Basket Survey of NHMRC and the National Residue Survey coordinated by the Federal Department of Primary Industries and Energy.

Australian Market Basket Surveys were conducted in 1970, 1973, then annually until 1987. The next is a two-year survey, covering 1988/89. Reports of the 1985, 1986, and 1987 surveys, published during and since 1987 (e.g. Anon 1988a), have included results for the heavy metals lead and cadmium. Lead has been included in all surveys since 1970; the first survey for cadmium was conducted in 1974 (Anon 1988b).

Copper levels in butter were examined in the 1975 Market Basket Survey only, while monitoring of zinc in foods has not occurred since 1978. Levels of selenium and aluminium were determined in selected foods sampled for the 1987 Market Basket Survey. The practice for these Market Basket Surveys has been to purchase food samples in the capital cities in each of three randomly selected metropolitan areas in three buying seasons during the survey period. Foods are washed and processed as necessary to a 'table-ready' condition, and analysed following removal of inedible material.

In contrast, the Australian National Residue Survey (NRS), which has operated since the mid-1960s, is designed to monitor chemical contaminants – including cadmium, lead and mercury – in agricultural food commodities. It was expanded in November 1985 to cover produce intended for the domestic market (Anon 1988c). The four food

Table 3. Some maximum international food standards for heavy metals with some bias to seafoods and cadmium (Cd).

Country	Details	Reference
Bangladesh	Cd: 6 mg/kg in all foods	1
Brazil	Cd: 1 mg/kg for foodstuffs other than beverages, including fruit juices	1
Bulgaria	Cd: 0.05 mg/kg in fish and fish products	2
Chile	Cd: 0.05 mg/kg in all foods	1
Colombia	Cd: 5 mg/kg for all foods	1
CSSR	Cd: 0.05 mg/kg in fish and fish products	2
Cuba	Cd: 0.05 mg/kg in fish and fish products	2
Denmark	Cd (mg/kg): monitoring limit of 0.3 for fish and 0.5 for molluscs; 0.5 for fish products (river fish; flounder, tuna, bonito or cod) Cd (mg/kg): rejection limit of 0.5 mg/kg for fishliver; action levels of 0.05 for fish and fish products, 0.5 for crustaceans and molluscs Hg (mg/kg): rejection limits of 0.3 for fish and fish products, 0.5 for flounder, tuna, bonito or cod, 1.0 for eel, halibut and freshwater fish; action limits of 1.0 for porbeagle and 0.3 for crustaceans/molluscs Pb (mg/kg): action levels of 0.3 for fish & fish products, 1.0 for crustaceans/molluscs.	1 3 3 3
GDR	Cd: 0.05 mg/kg in fish and fish products	2
Hong Kong	Cd: 2 mg/kg for fish and fish products	1
Hungary	Cd: 0.3 mg/kg in fish and fish products or 0.05 mg/kg in same	1 2
India	Cd: 1.5 mg/kg in all foods	3
Korea	3 mg/kg for total heavy metals	3
Malaysia	Cd: 1.0 mg/kg in all foods	1
Mongolia	Cd: 0.05 mg/kg in fish and fish products	2
Netherlands	Cd (mg/kg): guideline levels of 0.05 for fish, 0.3 for crustaceans, and 1.0 for other shellfish	1
Pakistan	Cd: 6 mg/kg for all foods	1
Poland	Cd: 0.05 mg/kg in fish and fish products	2
Spain	Cd (mg/kg): 1.0 for crustaceans & provisional 1.0 for other shellfish	1
Uruguay	Cd: 5 mg/kg for all foods	1
USSR	Cd: 0.05 mg/kg in fish and fish products	2

1. Walker (1988)
2. Unpublished UNEP/WHO data from Council for Mutual Economic Assistance
3. Anon (1989e)

commodity groupings covered are meat, dairy products, grains and grain products, and fruit and vegetables. Fresh seafoods have been neglected but this situation is likely to change in the near future.

Objectives of the NRS are to confirm the acceptability of agricultural food commodities for export and domestic markets, to provide residue data for trade negotiations, to offer objective assessment of contaminant risks associated with different food commodities, to give early warning on potential contaminant problems, and to provide background information to facilitate control of undesirable contaminants. The commodities are surveyed on a state by state basis to obtain a national perspective.

References

Anon (1986), *National dietary survey of adults: 1983, No. 1, Foods Consumed*, Australian Govovernment Publishing Serervice, Canberra.

Anon (1987a), *Food Standards Code 1987*, Australian Government Publishing Service, Canberra.

Anon (1987b), *Codex Alimentarius Commission - Report of the seventeenth session, Rome, 29 June-10 July 1987*, FAO/WHO, Rome.

Anon (1988a), *The Market Basket (Noxious Substances) survey 1986*, Australian Government Publishing Service, Canberra.

Anon (1988b), *Review of the Australian Market Basket Survey*, Unpublished Draft Report.

Anon (1988c), *Report of the National Residue Survey 1986 Results*, Australian Government Publishing Service, Canberra.

Anon (1989a), *Codex Alimentarius Commission - Report of the eighteenth session, Geneva, 3-12 July 1989*, FAO/WHO, Rome.

Anon (1989b), Requirements for Clearance of Agricultural and Veterinary Chemical Products, First Addition. Australian Agricultural and Veterinary Chemicals Council, Australian Government Publishing Service, Canberra.

Anon (1989c), *Controls on the clearance, registration and use of agricultural and veterinary chemicals*, Victoria Dept. of Agriculture and Rural Affairs, Melbourne. (Technical Report Series No. 182)

Anon (1989d), 'This Week. Polluted prawns on paradise islands', *New Scientist*, 18 November.

Anon (1989e), Joint FAO/WHO Food Standards Programme, Codex Committee on Food Additives and Contaminants, 21st Session March 1989, unpublished draft report.

Anon (1990), 'Towards a closer partnership', *The Australian*, 1 November.

Hamilton, D. (1988), Setting MRL values for pesticides in foods. *Queenslandd Agricultural Journal*, Jul.-Aug., 225-8.

Hutton, H. (1987), 'Human health concerns of lead, mercury, cadmium, and arsenic', In *Lead, Mercury, Cadmium and Arsenic in the Environment*, T.C. Hutchinson and K.M. Meema (eds), John Wiley & Sons, Brisbane.

Lansdown, R. (1979), 'Moderately raised blood lead levels in children', *Proceedings of the Royal Society*, London, 205, 145-51.

Shaper, A.G. (1979), 'Cardiovascular disease and trace metals', *Procedings of the Royal Society*, London, 205, 135-43.

Tanenaka, S., Oldiges, H., Konig, H., Hochrainer, D. and Oberdorster, G. (1983), 'Carcinogenicity of cadmium chloride aerosols in Wistar rats', *Journal of the National Cancer Research Institute*, 70, 367-73.

Waldron, H.A. (1973), 'Lead poisoning in the ancient world', *Medical History*, London, 17, 391-9.

Walker, J.M. (1988), 'Regulation by other countries of cadmium in foods and the human environment', *Proceedings No 2 "Cadmium Accumulations in Australian Agriculture: National Symposium, Canberra, 1-2 March 1988"*, Australian Government Publishing Service, Canberra, 176-85.

WHO (1985), *Review of potentially harmful substances - cadmium, lead and tin.*, WHO, Geneva. (Reports and Studies No. 22. IMO/FAO/UNESCO/WMO/WHO/IAEA/ UN/ UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution)